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REFERENCE:
(a) Definitive Contract AF04(695)-113, Exhibit "A"
(b) AFBM Exhibit 58-1, Paragraph 4.2.1
(c) AFSSD Exhibit 61-27A, Paragraph 1.2.1.?

In accordance with References (a), (b), and (c), we are forwarding one (1) copy of the following document:

Title	No. and Date
Apogee Determination for an Eccentric Orbit of High Altitude	WDL-TN-62-6, Revision 1 25 January 1963

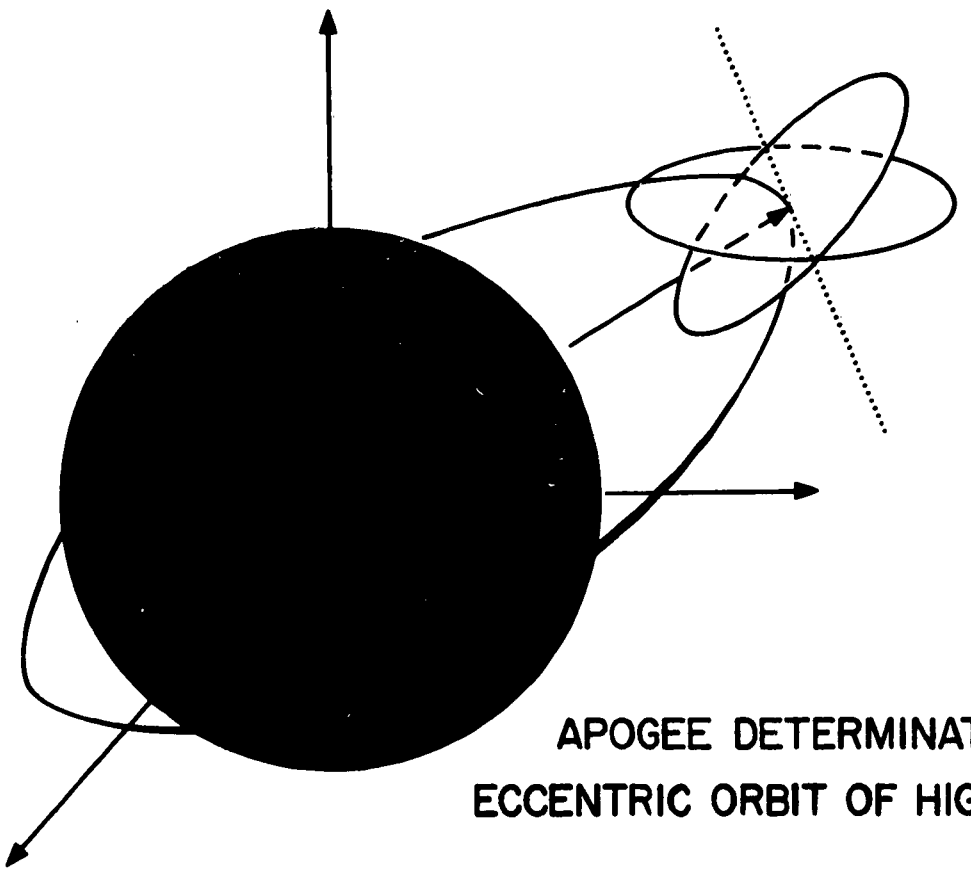
PHILCO CORPORATION
Western Development Laboratories

R. W. Boyd

R. W. Boyd
Manager, Contracts Management

TECHNICAL NOTE

WDL-TN62-6, REVISION I
25 JANUARY 1965



APOGEE DETERMINATION FOR AN ECCENTRIC ORBIT OF HIGH ALTITUDE

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CONTRACT AF04(695)-113

PHILCO
A SUBSIDIARY OF Ford Motor Company
WESTERN DEVELOPMENT LABORATORIES

WDL-TN62-6
Revision 1

TECHNICAL NOTE

APOGEE DETERMINATION FOR AN ECCENTRIC ORBIT OF HIGH ALTITUDE

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Definitive Contract AF04(695)-113
AFBM Exhibit 58-1, Paragraph 4.2.1

Prepared for

SPACE SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
Inglewood, California

ABSTRACT

PHILCO WDL-TN62-6, Revision 1 — UNCLASSIFIED

APOGEE DETERMINATION
FOR AN ECCENTRIC ORBIT
OF HIGH ALTITUDE

25 February 1963 — 14 pages
Contract AF04(695)-113

This Technical Note presents the results of a preliminary study, of an orbit having a 50,000 n. mi. apogee, a 200 n.mi. perigee, and an inclination plane of 33 degrees, to determine how well the satellite's position could be predicted at its first apogee. Results for a range of equipment accuracies and for various combinations of data are presented graphically.

THIS UNCLASSIFIED ABSTRACT IS DESIGNED FOR RETENTION IN A STANDARD 3-BY-5 CARD-SIZE FILE, IF DESIRED. WHERE THE ABSTRACT COVERS MORE THAN ONE SIDE OF THE CARD, THE ENTIRE RECTANGLE MAY BE CUT OUT AND FOLDED AT THE DOTTED CENTER LINE. (IF THE ABSTRACT IS CLASSIFIED, HOWEVER, IT MUST NOT BE REMOVED FROM THE DOCUMENT IN WHICH IT IS INCLUDED.)

FOREWORD

Technical Note WDL-TN62-6 has been prepared by the Philco WDL Mathematical Analysis Department for submittal to AFSSD for information purposes. This Technical Note is within the scope defined by Paragraph 4.2.1, AFBM Exhibit 58-1, "Contractor Reports Exhibit," dated 1 October 1959, as revised and amended.

The material presented in the Technical Note was developed in conjunction with Tracking Simulation and Evaluation and Advanced Trajectory Analysis Studies conducted by Philco WDL under Exhibit "A" of Definitive Contract AF04(695)-113, and Paragraph 1.2.1.2 of AFSSD Exhibit 61-27A, "Satellite Control Subsystem Work Statement," dated 15 February 1962.

APOGEE DETERMINATION FOR AN ECCENTRIC ORBIT OF HIGH ALTITUDE

The fixed bias covariance computer program[1] was used to determine the errors in predicted position resulting from various equipment accuracies for an orbit with the following characteristics:

Apogee	50,000 n. mi.
Perigee	200 n. mi.
Inclination of Orbital Plane	33 deg.

This paper presents the results of the preliminary study of this orbit. The main objective of the study was to determine how well the satellite's position could be predicted at its first apogee. The prediction was made for a range of equipment accuracies (indicated on the graphs) and for various combinations of data on the time interval from 0 minutes (perigee) to 1650 minutes (post-apogee).

Tracking data [slant range (S), antenna azimuth (A), antenna elevation (E)] were obtained from two stations. The first observational pass occurred from time 14 minutes to 692 minutes and the second from time 564 minutes to 812 minutes, where time 0 was the time of injection into orbit. Apogee was at time 933 minutes. The sample rate was one sample every two minutes. The errors in the data were either randomly distributed with mean of zero and a given standard deviation (indicated on the graphs by σ) or fixed-bias errors (indicated on the graphs by Δ). The weighting factors assigned to each set of data were the reciprocals of the standard deviations or fixed biases, except when the equipment accuracy is designated by 0, in which case the weighting factor was also 0.

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[1] A discussion of simulation techniques to determine the effects of tracking equipment error on satellite prediction, containing details of the program, will be presented in Philco WDL Report WDL-TN62-1, to be published.

The tracking equipment accuracies are indicated on the graphs in the following manner:

$$\left[\sigma_S,\ \sigma_A,\ \sigma_E\right]$$

or

$$\left[\Delta S,\ \Delta A,\ \Delta E\right]$$

When 0 is given as an equipment accuracy, the 0 weighting factor given it causes the orbit determination to be based only on the remaining data. Thus, orbit determination has been made from slant-range-only data, angles-only data, and various combinations of these data. In some instances, several tracking accuracy triplets occur on one graph. This situation will indicate the predominance of one tracking parameter. Variations in the remaining parameters have no appreciable effect on the resulting position prediction and the same set of prediction errors are common to several accuracy triplets. Figure 1 is an example. In this case the five listed triplets produced equivalent sets of errors in predicted position, with the range accuracy of 0.1 nautical miles predominating.

Figures 1 through 7 present errors in predicted position based on slant range and angle data. The measure of error shown is a root mean square of errors in an orthogonal system local to the vehicle.

$$\text{RMS error} = \left[x_1^2 + x_2^2 + x_3^2\right]^{\frac{1}{2}} \qquad \text{where}$$

$x_1 (=\xi)$ = error in the orbital plane and in the direction of the velocity vector.

x_2 = error in the orbital plane and normal to the velocity vector.

x_3 = error normal to the orbital plane and normal to the velocity vector.

Figures 8 through 11 present the component of the error in the direction of the velocity vector.

In past analyses, where predictions were made for several revolutions of the vehicle, a periodic variation in positional error could be observed. That same variation exists here but is less apparent since positional error was computed for less than one revolution.

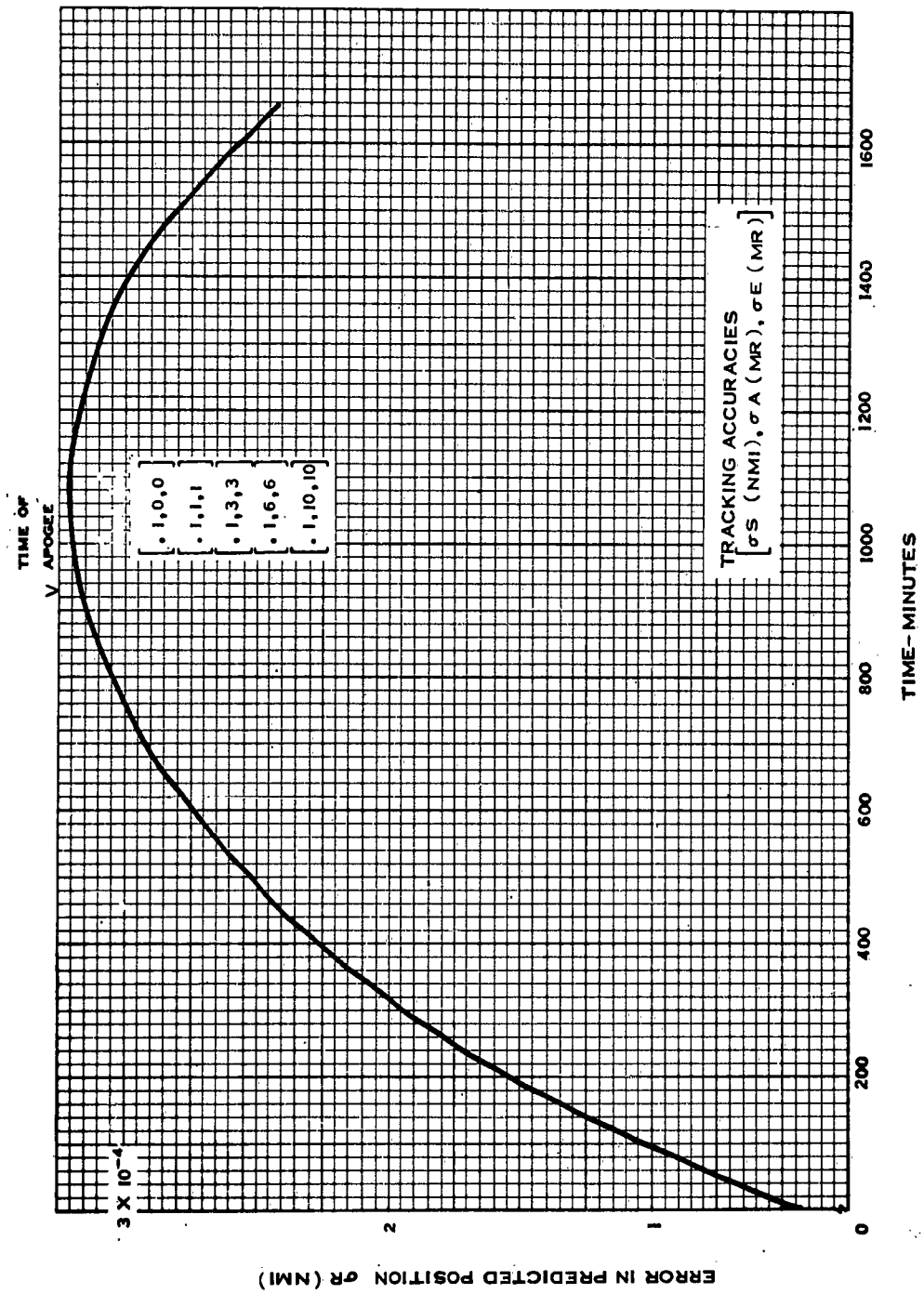

Fig. 1 Apogee Determination: 200 NMI Perigee - 50,000 NMI Apogee (Random Error)

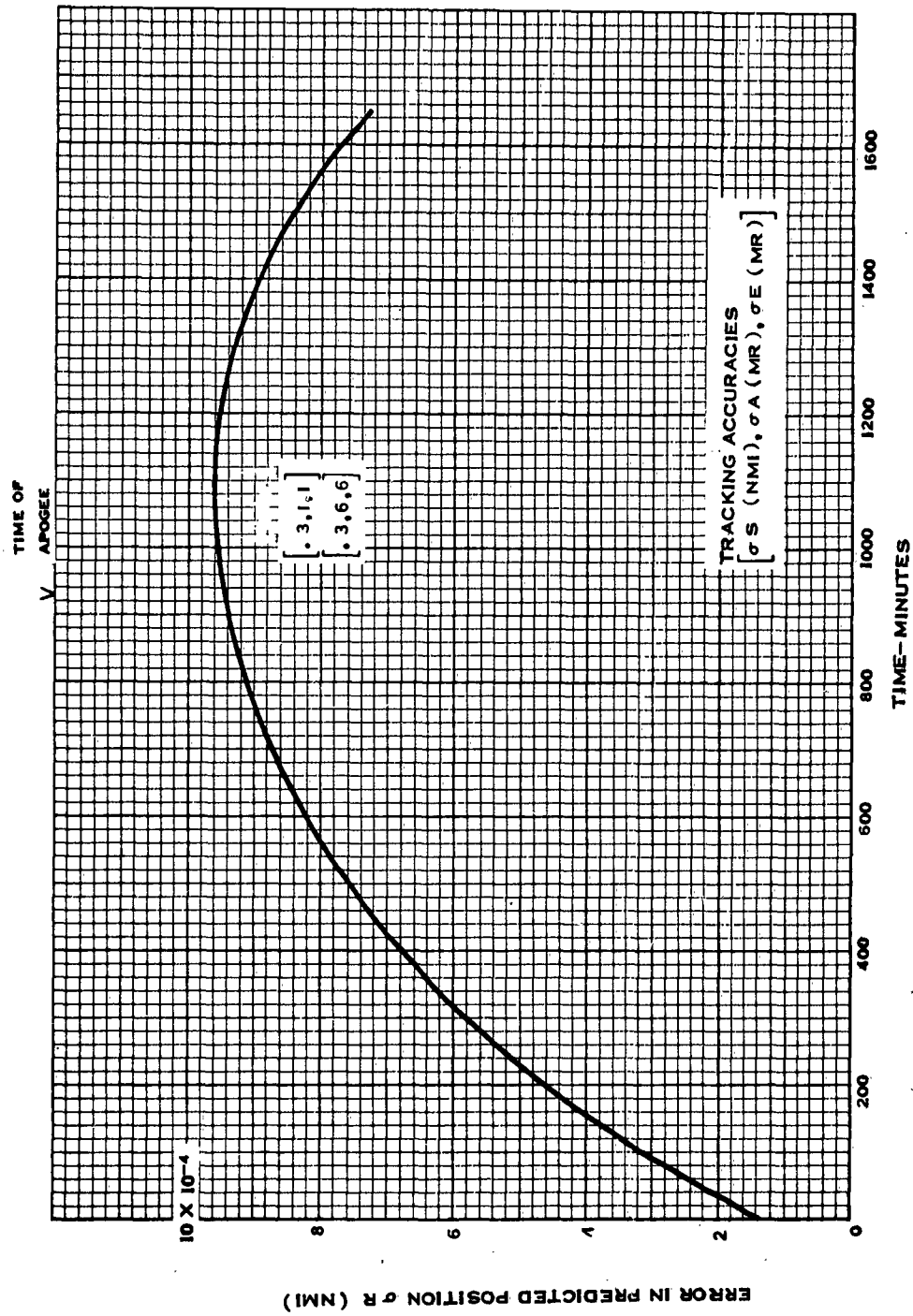

Fig. 2 Apogee Determination: 200 NMI Perigee - 50,000 NMI Apogee (Random Error)

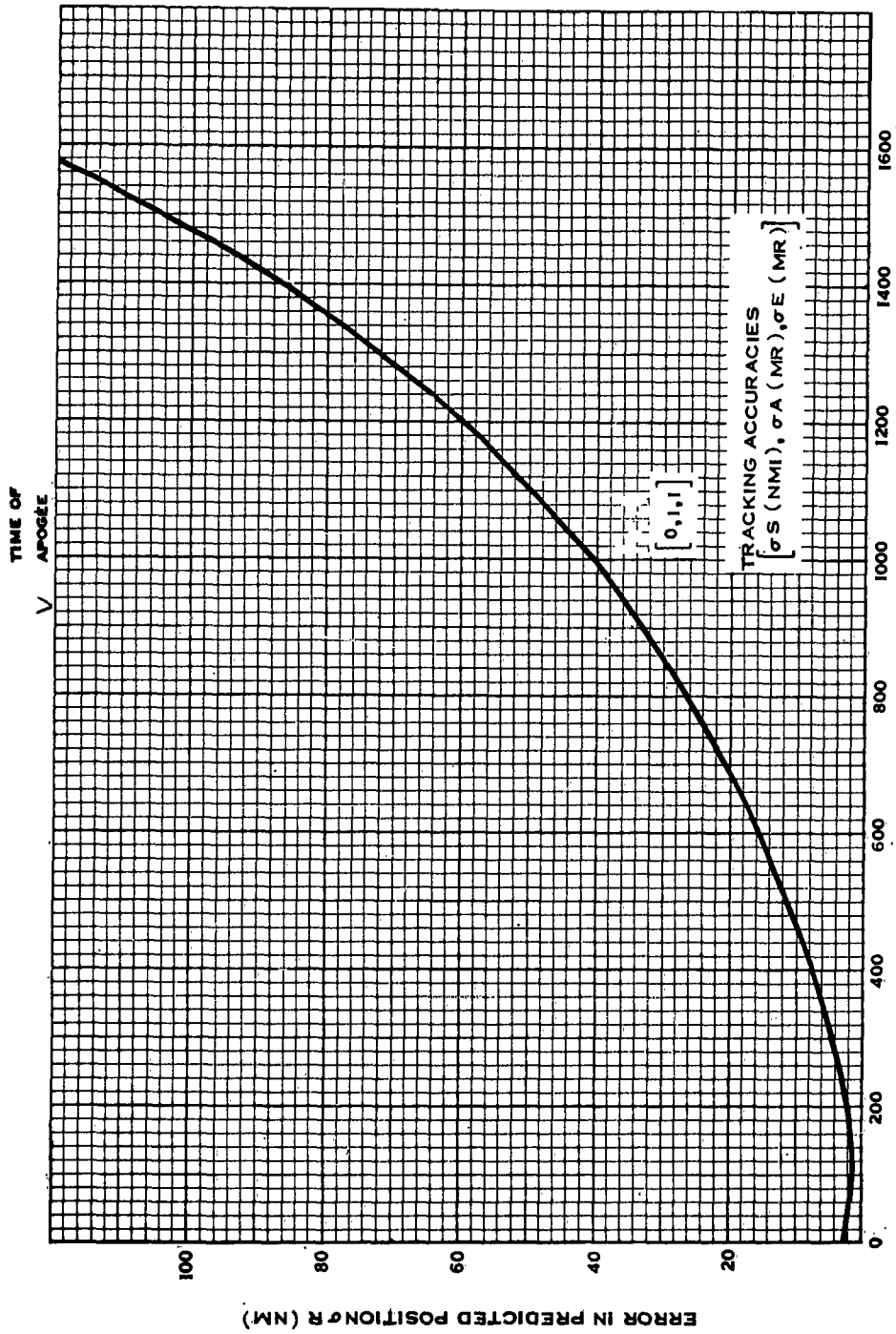

Fig. 3 Apogee **Determination:** 200 NMI Perigee - 50,000 NMI Apogee (Random Error)

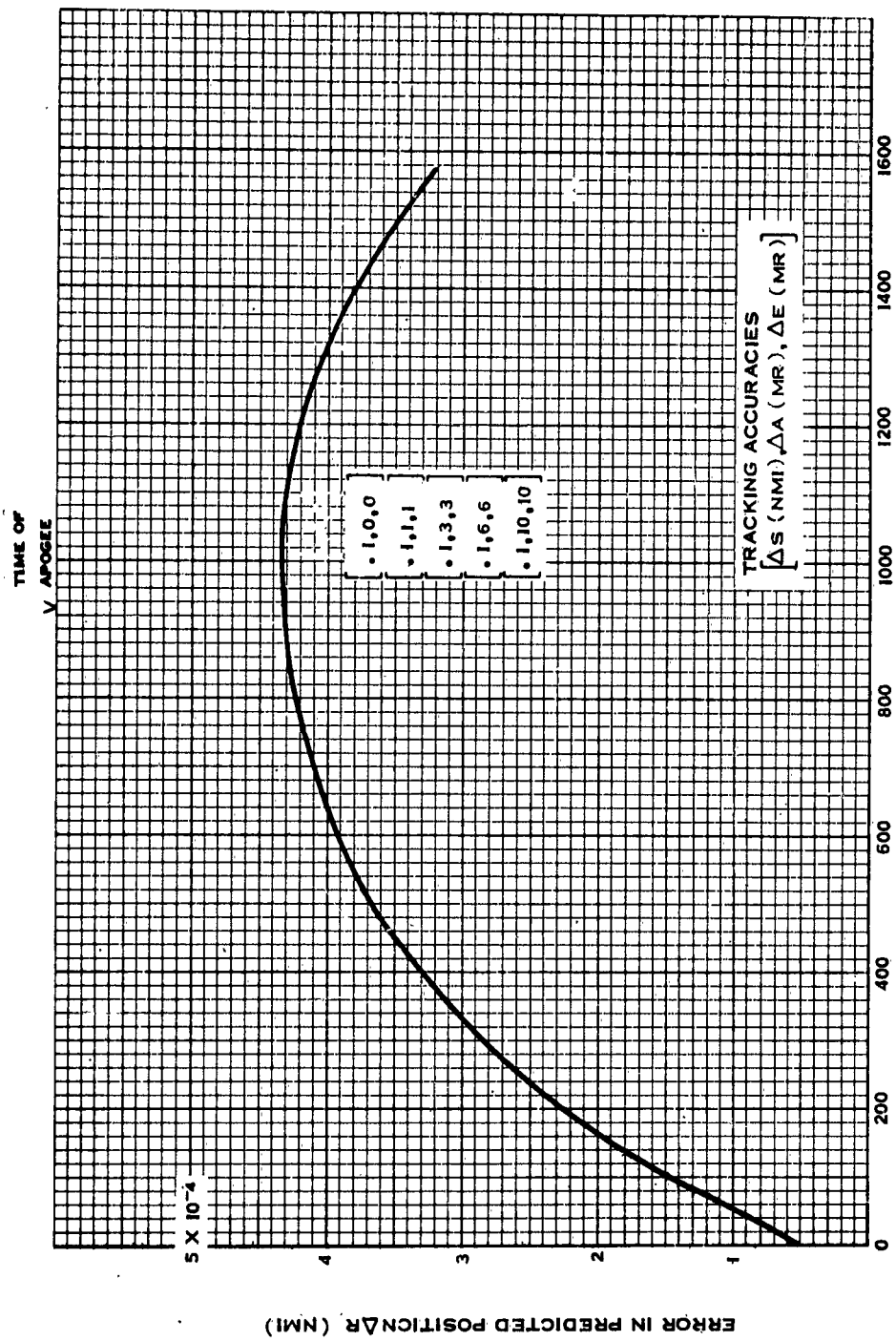

Fig. 4 Apogee Determination: 200 NMI Perigee - 50,000 Apogee (Bias Error)

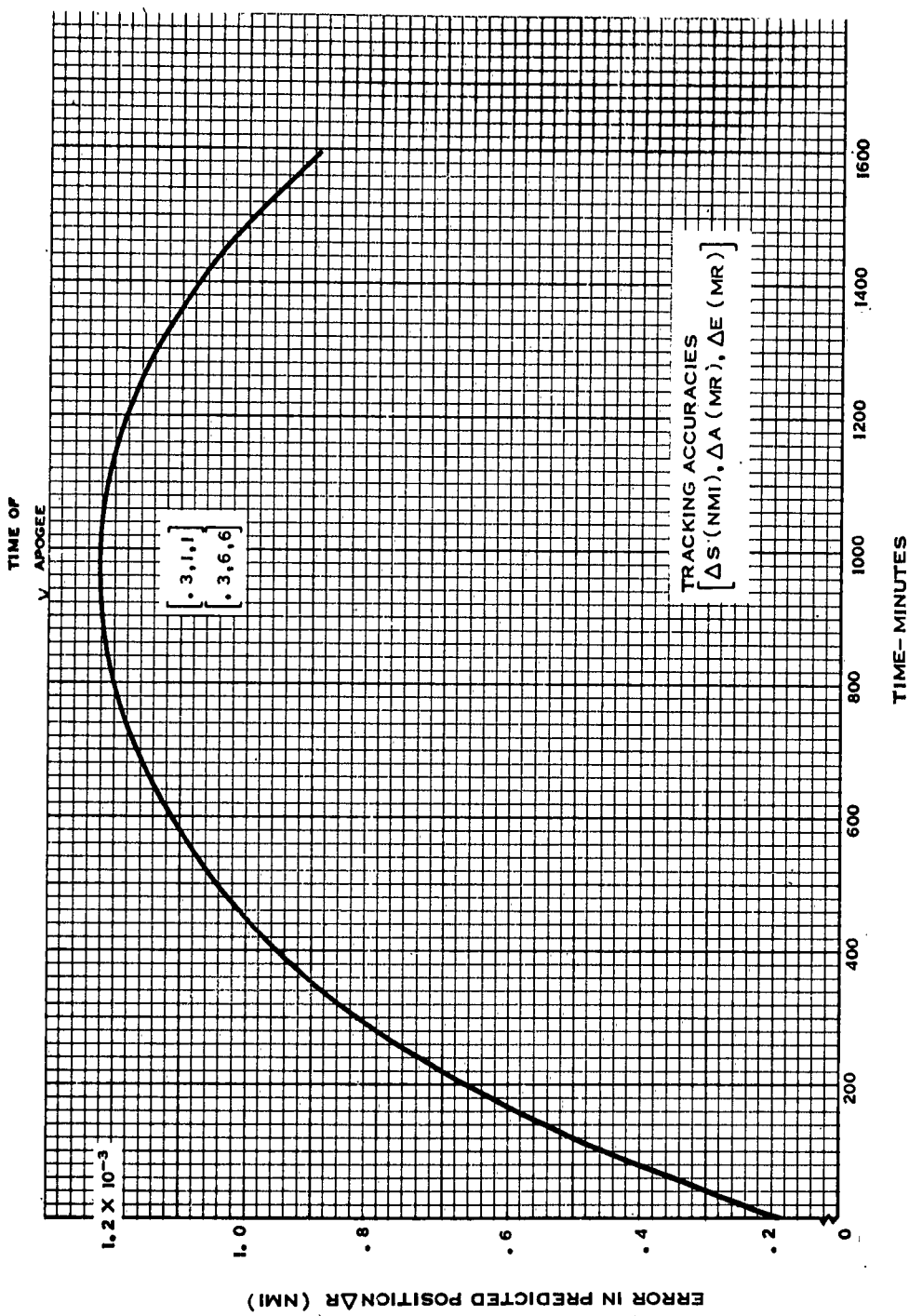

Fig. 5 Apogee Determination: 200 NMI Perigee - 50,000 NMI Apogee (Bias Error)

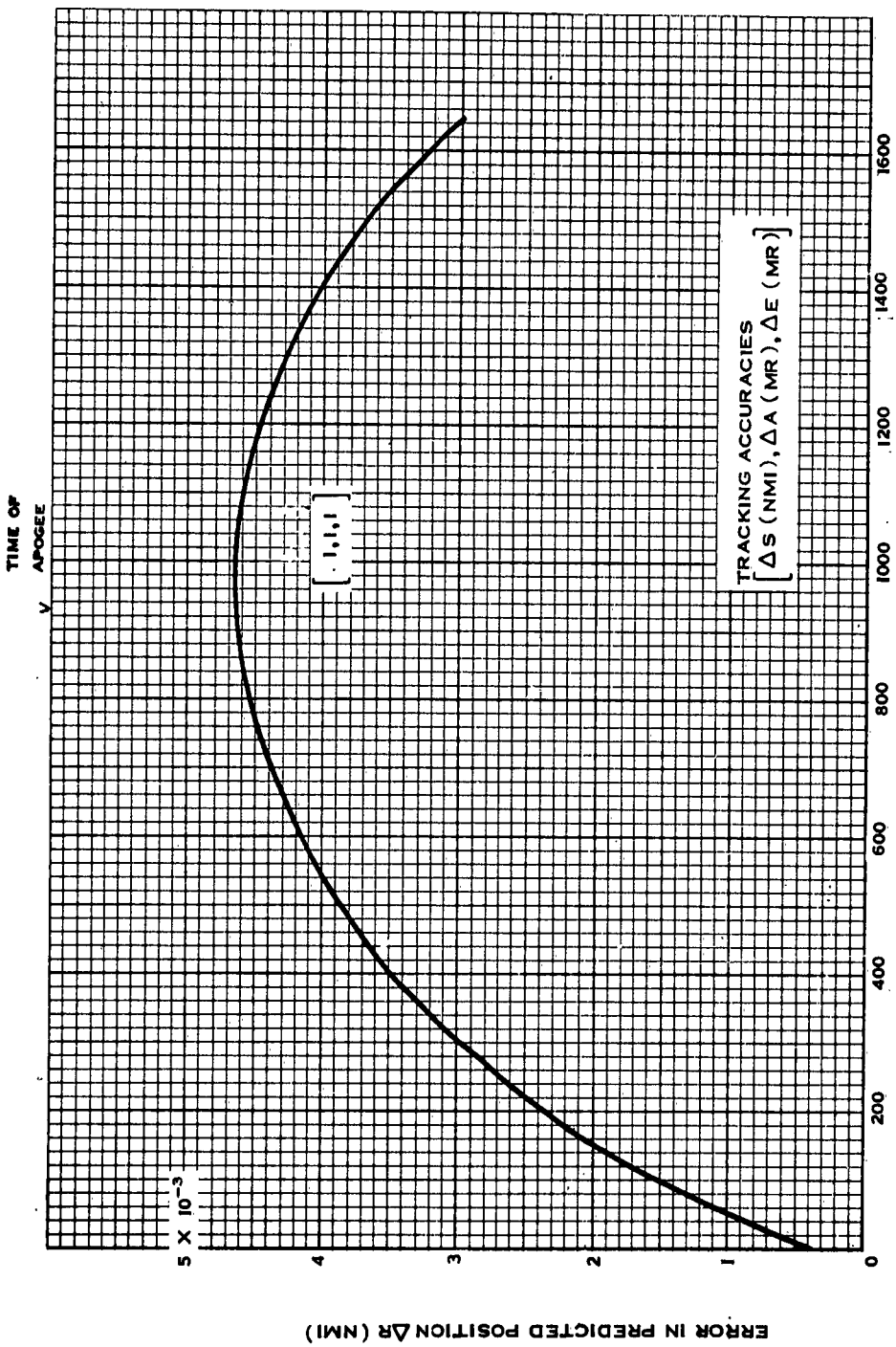

Fig. 6 Apogee Determination: 200 NMI Perigee - 50,000 NMI Apogee (Bias Error)

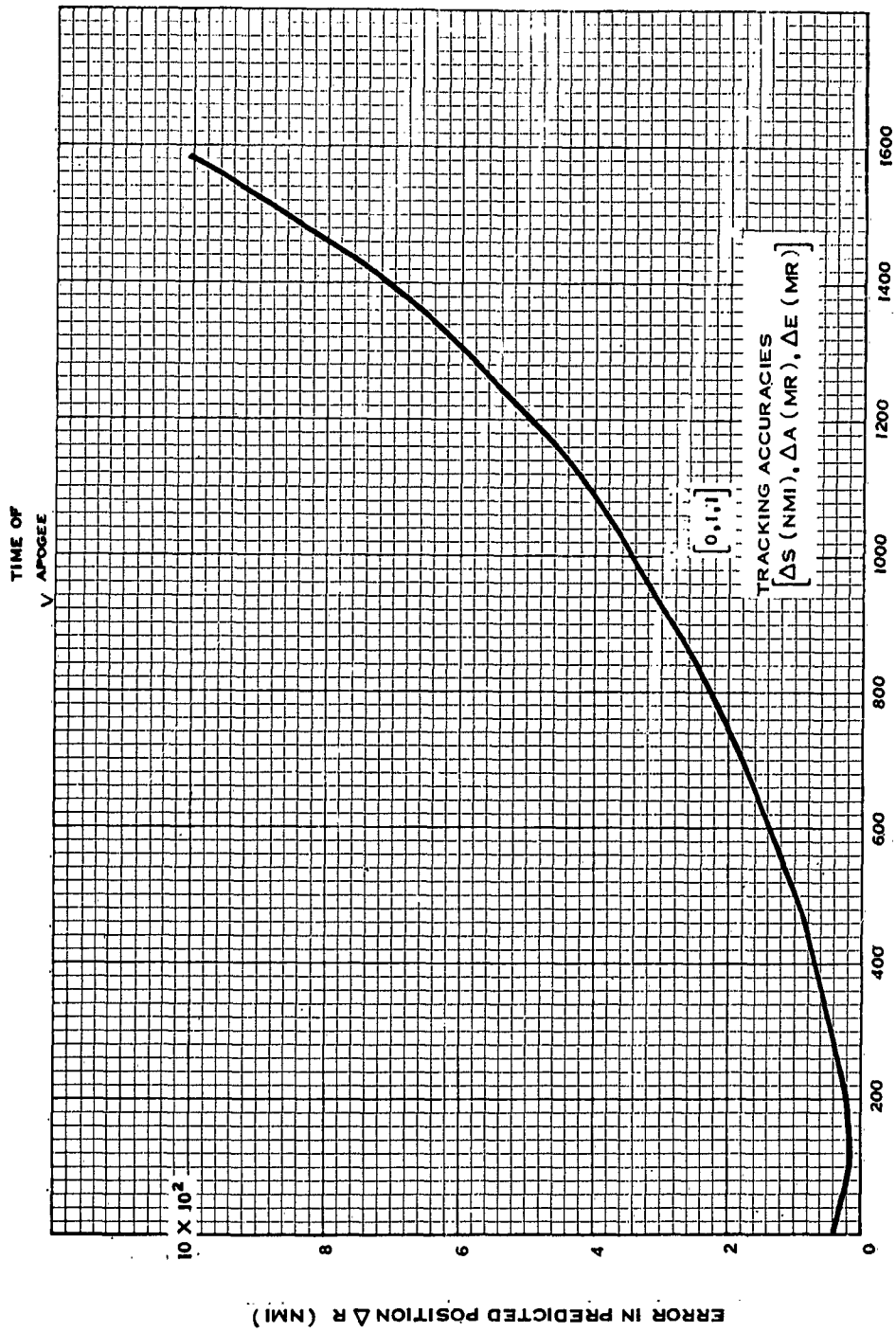

Fig. 7 Apogee Determination 200 NMI Perigee - 50,000 NMI Apogee (Bias Error)

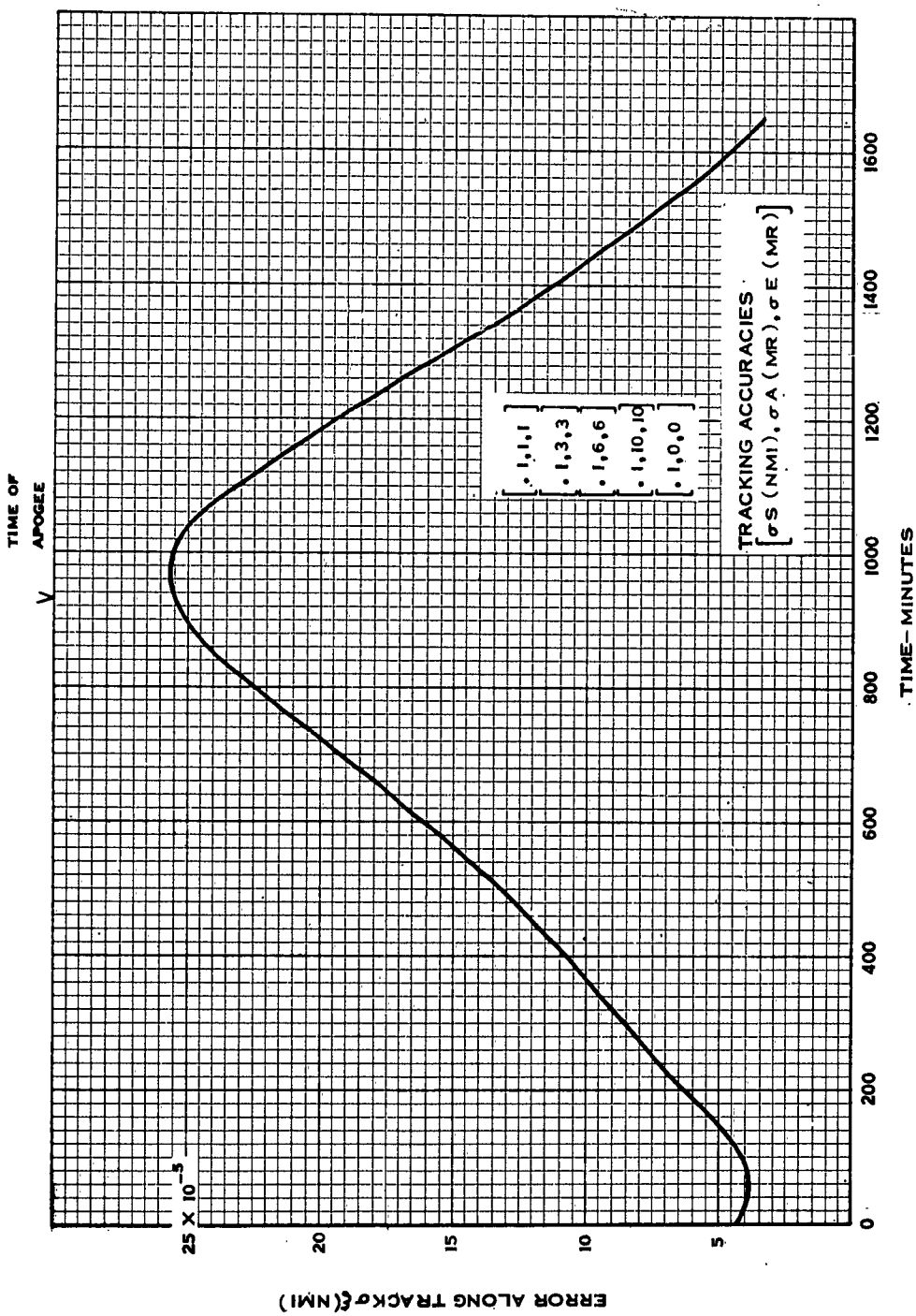

Fig. 8 Apogee Determination : 200 NMI Perigee - 50,000 NMI Apogee (Random Error)

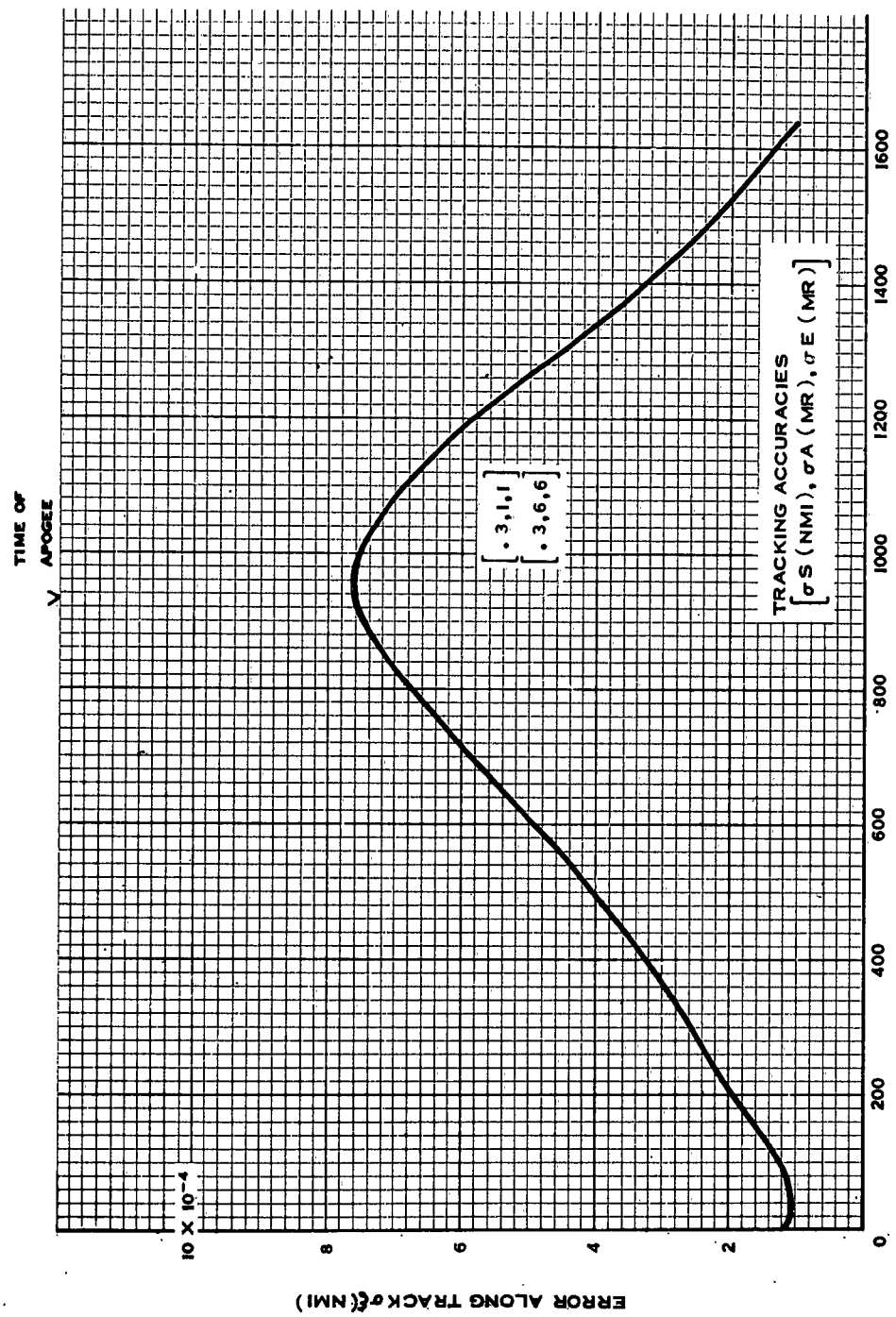

Fig. 9 Apogee Determination: 200 NMI Perigee - 50,000 NMI Apogee (Random Error)

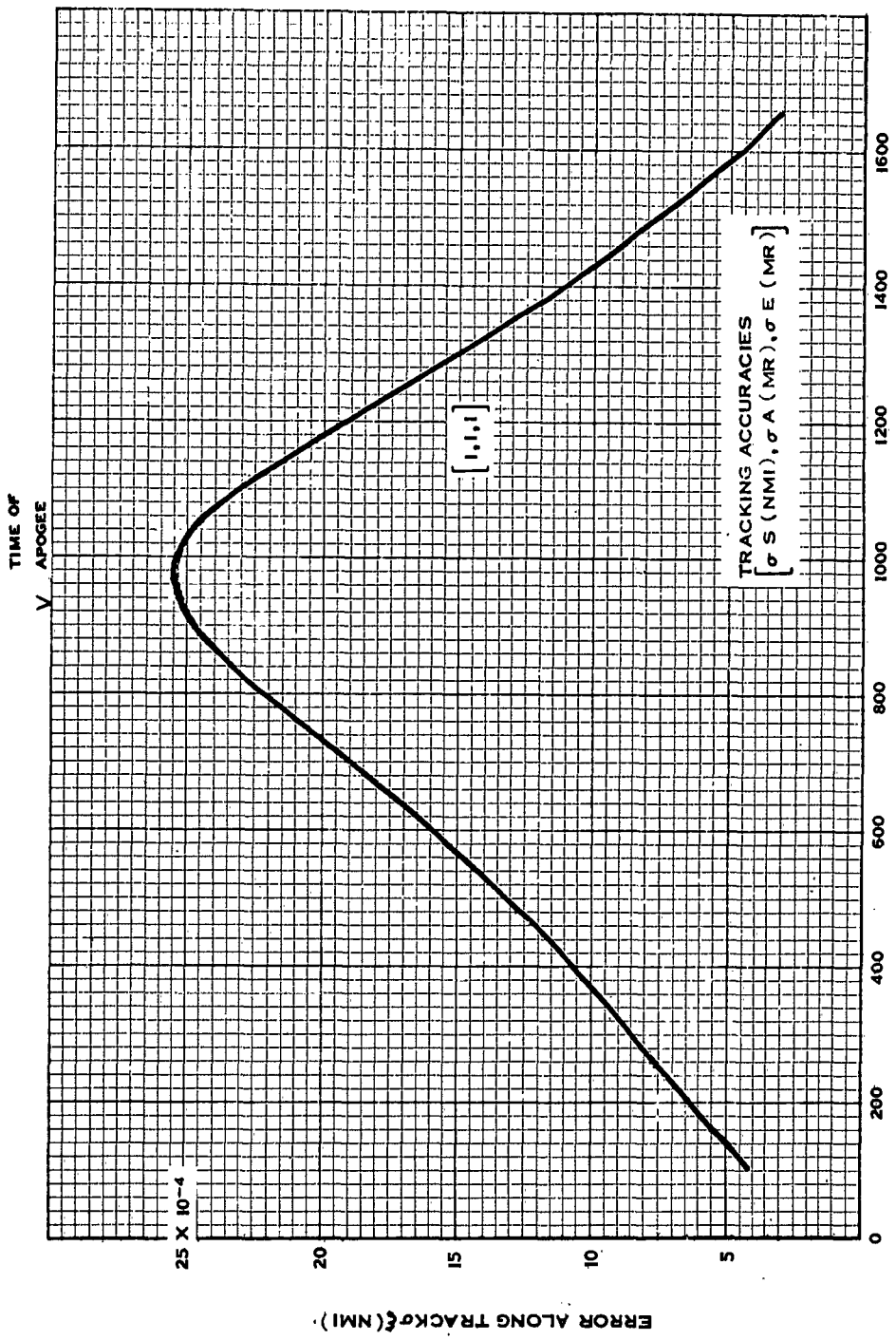

Fig. 10 Apogee Determination: 200 NMI Perigee - 50,000 NMI Apogee (Random Error)

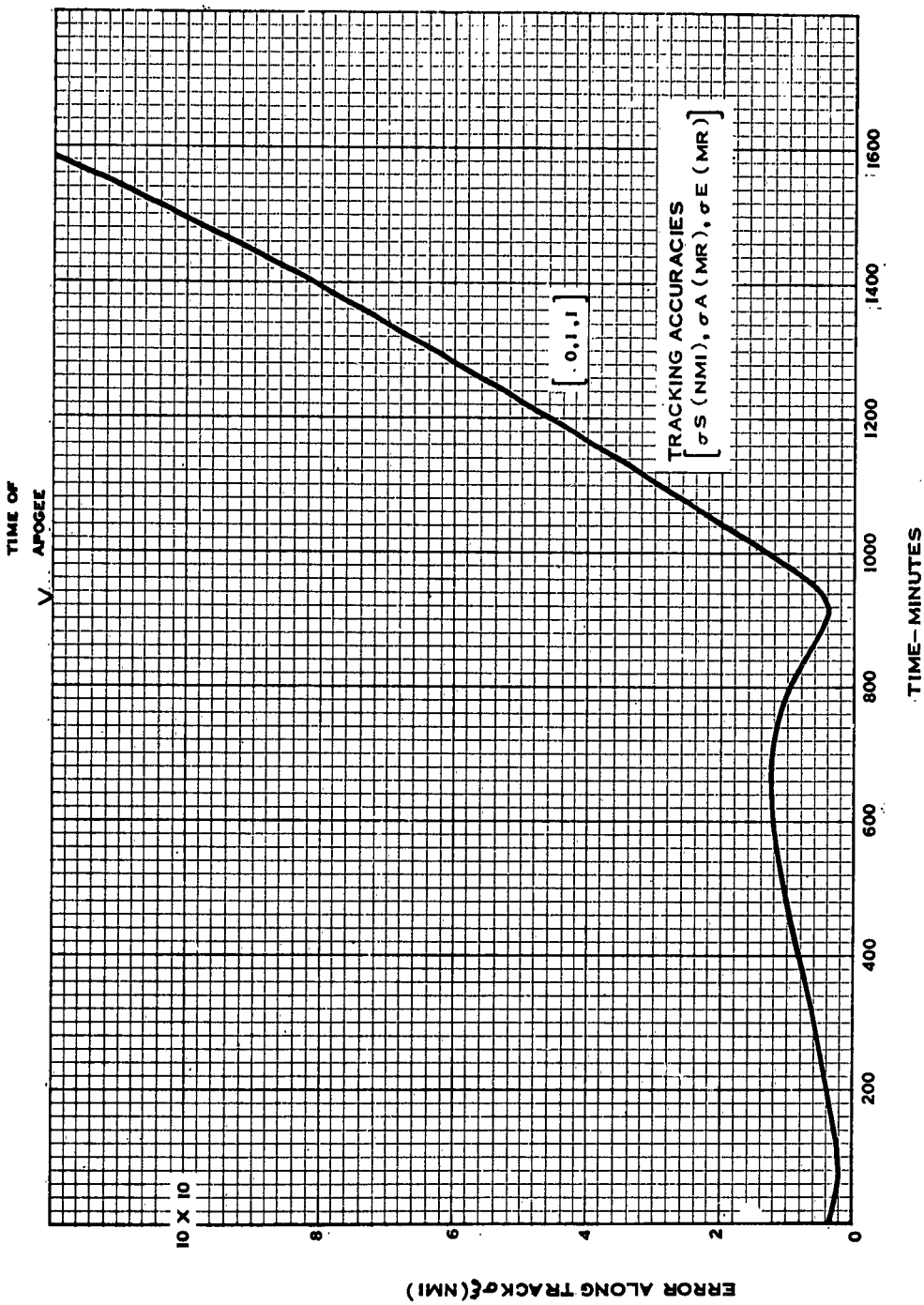

Fig. 11 Apogee Determination: 200 NMI Perigee - 50,000 NMI Apogee (Random Error)

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